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Device and method for producing a hollow section or shell section

The invention relates to a device for producing a hollow section or shell section according to the preamble of patent claim 1 and to a method for this according to the preamble of patent claim 6.

During hydroforming, contoured hollow sections or half shells are produced from surfaces placed one on top of the other (during "sheet blank expansion") or from tubular blanks by the sheets or tubular blanks being inserted in a sealing manner in a die of an HF tool and by an introduced fluid being applied at a corresponding high pressure to said sheets or tubular blanks in order to form the latter. The hydroforming process is used specifically in the production of frame structure components in the automobile sector, for example for the production of body members.

Such frame structure components have to be connected to other surrounding components. In the conventional production of frame structure components, flanges are generally provided at the ends of the components for connecting to the surrounding components in order to permit an appropriate connection to other components, for example by spot welding.
For this purpose, components produced by means of hydroforming are subsequently subjected to further processing steps, such as cutting or bending for example. To this end, the hollow section or shell profile produced must be deflected to the desired length in a separate processing step. Whereas flat cut contours can in this

case still be produced by a simple saw cut running transversely to the axial/longitudinal direction of the hollow section or shell section, cut contours running in three-dimensional space for flange surfaces, which are increasingly occurring in particular in the use of frame structure components in vehicle body construction, have to be produced in an elaborate manner by laser or plasma cutting. The flanges are then produced by subsequent bending of the material pieces or extensions still remaining on the workpiece.

It goes without saying that such subsequent processing steps require additional processing machines. In addition, the components have to be transported from the HF device to the subsequent processing stations. These circumstances lead to an increased expenditure of time and to considerably higher production costs.

In order to carry out cutting in an HF tool, a device is proposed in EP 100 43 81 A2 establishing the generic type, this device comprising die plates, integrated in the tool and having cutting edges, and a plurality of support plungers which bear axially against said die plates, both the die plates and the plungers being provided at the periphery at one end of the hollow section blank to be formed. The end of the blank projects from the HF tool. During the expansion of the blank by introducing the fluid under high pressure, the periphery of the blank butts against the cutting edges. The support plungers, which are pushed toward the hollow section blank via drive wedges by hydraulic or pneumatic cylinders until they come to bear against one another, form a small peripheral gap with the hollow section blank in this phase, so that, by continuing the expansion, the end of the blank is pre-cut at the cutting edges. The drive wedge is then retracted, as a result of which the

plungers are lowered in the bottom tool part. In this way, the peripheral gap in the bottom region of the blank is markedly increased and the blank shaped into the desired hollow section is completely cut off there at the end at the cutting edges. However, the plungers in the top tool part remain in their previous position due to gravitational force, while the drive wedges move outward. On account of the expanding hollow section, the plungers are pushed apart, after which the cutting edges are exposed. Since the cutting edges, due to the lowering of the plungers in the bottom tool part, are exposed much earlier than in the top tool part, the trimming in the bottom tool part is effected earlier than in the top tool part. During the trimming, however, a pressure drop occurs in the hollow section, so that only the bottom peripheral region of the hollow section is severed neatly. In the top region, either no complete parting is effected or the parting contour of the hollow section is at least undefined there, so that a rework operation is inevitable in order to completely sever the initially cut top region or to transfer the parting contour into the desired mold profile. This is complicated for the entire process of producing the hollow section and is affected by production tolerances on account of the additionally required transfer to a suitable parting or rework device. In addition, the cut contour is in this case determined over the periphery of the section by the shape of the cutting edges. Since the die plates bear symmetrically against the periphery of the HF component in the present case, this device is only suitable for hollow sections having a rotationally symmetrical or rectangular cross section. However, the tongues formed on the end of the hollow section by the trimming can be used as fastening flanges after a resetting operation.

Based thereon, one object of the present invention is to

provide a device and a method for hydroforming, in which production of HF components having joining flanges connected to them in one piece is made possible in a relatively simple manner.

The object is achieved according to the invention by the features of patent claim 1 according to the device and by the features of patent claim 6 with regard to the method.

On account of the formation of notches by means of notching punches which are displaceable in the radial direction relative to the hollow section or shell section, defined parting points are created between the lateral notch margins running in the component longitudinal direction, these parting points being parted by a parting device separate from the punches, with the extension section and a cut-off component which exposes the component to be produced being formed. After removal of the hollow section or shell section thus produced, the extension sections are bent over outside the HF tool to form a flange section in each case by means of a bending device. This constitutes a simple production method, the acting tools forming the extension sections in a reliable and exactly reproducible manner. By means of the notching punches, the arrangement and shape of the notches is relatively flexible. Thus said notching punches need not necessarily form a rectangular shape, but rather, according to requirements, can produce triangular or polygonal shapes, which, according to requirements, can have virtually any desired contour. Therefore very diverse shapes of the component ends of a hollow section or shell section can already be produced in the HF tool in a highly precise manner. The notching punches may themselves have cutting edges at their end face, with which cutting edges they act upon the hollow section or shell section in a cutting manner and punch a notch slug

out of the latter from outside into the interior of the hollow section or shell section.

At the same time, however, it is also conceivable for the notching punches for producing the notches to give way relatively quickly in their passage and in the process expose a cutting edge at the orifice opening of the passage, this cutting edge being formed on the cavity of the die of the HF tool. In this way, driven by the internal high pressure, on account of the resulting contact pressure of the hollow section or shell section on the cavity of the die at the location of the notch to be produced, a hole slug is cut out into the passage of the notching punches via the cutting edge of the cavity. The hole slug becoming jammed in the passage can be pressed out of the passages later in a simple manner, for example by advancing the notching punches, after removal of the hollow section or shell section from the tool, it being necessary to place a collecting device in the region of the passages, which prevents the hole slugs from falling into the empty cavity.

Care must always be taken when forming the notches to ensure that the notching punches provide a sufficient seal or are sealed sufficiently, so that a pressure drop inside the hollow section or shell section is prevented, which pressure drop would ruin a desired formation of the notches or of the extension sections to be formed. It may be emphasized at this point that three-dimensionally re-created and symmetrical cuts on the hollow section or shell section can be easily produced by a specific shape of the cutting edge of the end face of the notching punches or of the cavity, as a result of which the forming of the extension sections becomes especially variable.

In an especially preferred development of the invention as claimed in claim 2, the device according to the invention also comprises a cutting device which is separate from the punches and is intended for initially cutting the component along the terminating edge of the extension section to be produced and which is arranged inside the HF tool and directly adjoins the notching punches in the peripheral direction of the tool cavity. The parting device severing the component along the initial cut is arranged outside the HF tool. A predetermined parting point is achieved by the initial cutting of the component effected according to the method as claimed in claim 7, and this predetermined parting point, if need be, is extremely thin-walled and can be parted with the least possible effort outside the hydroforming tool by means of a parting device of simple construction. This may be done in such a way that the hollow section or shell section is simply knocked off at the thin point produced. Furthermore, the hollow section or shell section with the component to be parted can be removed in one piece as an entity from the HF tool, which considerably reduces the handling and transport cost. The cutting device in this respect may be designed, for example, in a simple manner as a knife-like cutting edge which plunges into the material of the hollow section or shell section and in the process severs the hollow section or shell section except for a thin web. The cutting device may in this case be arranged in the same axial position as the notching punches, since, even when the hollow section or shell section is acted upon from outside to inside by means of the notching punches, the cutting device in this case in no way gets into the clip-in region of the notching punches.

In a further preferred development of the device according to the invention as claimed in claim 3, the

device also comprises a cutting device which is separate from the notching punches and is intended for cutting through the component along the terminating edge of the extension section to be produced except for a thin, axial web adjoining the notch margins and which is arranged inside the HF tool and adjoins the notching punches at a slight distance apart in the peripheral direction of the tool cavity. The parting device severing the component at the location of the web is arranged outside the HF tool. Due to the formation of a thin axial web which results from the developed method according to the invention as claimed in claim 8, the parting operation by means of the parting device arranged outside the HF tool is facilitated on account of the material to be severed to a reduced extent. Owing to the fact that the cutting device now largely cuts through the hollow section or shell section, said cutting device, if it acts upon the hollow section or shell section in the same direction as the notching punches, would come into contact with the latter in such a way that the notching punches and the cutting device impair one another in an undesirable manner. Care is therefore to be taken in the case of an axially identical arrangement of cutting device and notching punches that the displacement movement of the notching punches runs in the opposite direction to the cutting device. The hollow section or shell section is in this case preferably cut from outside to inside by means of the cutting device, whereas the notches, via the notching punches giving way in the passages, are produced from inside to outside at the cutting edge of the cavity. In this variant, too, the component thus trimmed can also be removed as an entity in one piece from the HF tool. In the case where the cutting device consists of punches which have a knife-like end face, said punches are likewise displaceable, like the notching punches, although in separate passages and to this end can be

capable of being driven mechanically, pneumatically or hydraulically.

In an especially preferred development of the invention as claimed in claim 4, the parting device for cutting through the component along the terminating edge of the extension section to be produced is arranged inside the HF tool, in which case it directly adjoins the notching punches in the peripheral direction of the tool cavity but is axially offset from said notching punches in their engagement region. This has the advantage that the parting device is accommodated inside the HF tool in a space-saving manner and replaces the cutting device, with the outlay in terms of equipment and process being considerably reduced, without losing the function of the complete parting of the component to be cut off. Furthermore, the development of the device according to the invention advantageously allows the hollow section or shell section to be acted upon in the same direction by the notching punches and the parting device. Since the notching and the cutting-through of the component is as far as possible to be effected at the same time in order to avoid the risk of a pressure drop, the fact that the hollow section or shell section is acted upon in the same direction due to said arrangement of the parting device offers a considerable advantage for the process reliability of the production of the component with simultaneously reduced control outlay for the device. The cutting-through of the component effected according to the corresponding development of the method according to the invention as claimed in claim 9 by means of the parting device inside the HF tool along the terminating edge of the extension section to be produced can be carried out in a plurality of variants. In a special configuration of the device according to the invention as claimed in claim 5, the parting device may in this case

be formed by cutting punches. By means of these cutting punches, the component can be parted linearly in a simple manner along the abovementioned terminating edge during or after the notching. Alternatively, however, it is conceivable for the parting device to likewise consist of notching punches which sever the component simultaneously and produce notches in the cut-off component, so that a notching pattern with regard to a center cutting line in the form of alternating notches is obtained. This has the very special advantage that the cut-off component itself is a component that can still be used and need not be disposed of as a scrap part. The cut-off component in this case likewise has extension sections which can be bent over and can serve as fastening flanges. This parting of the component, to be cut off, from the hollow section or shell section need not necessarily be effected at the end, but rather may also be carried out centrally for example, in which case, if need be, identical parts with flanges can be produced from a single workpiece blank in a very economical manner in terms of the process.

Apart from that, it is also conceivable for it to be possible for such alternating notches to be formed in such a way that a thin axial web still remains which has to be parted outside the HF tool by means of the parting device. The notches on the component to be cut off are in this case made by the cutting device, which has to be of appropriate design.

The invention is explained in more detail below with reference to an exemplary embodiment shown in the drawings, in which:

fig. 1 shows a cutaway lateral longitudinal section of a hollow section in a hydroforming tool with axially

offset notching punches of the device according to the invention,

fig. 2 shows the device according to the invention according to figure 1 in a cross-sectional illustration along section line II-II from figure 1 during the notching operation,

fig. 3 shows, in a cross section, the device according to the invention from figure 1 along section line III-III from figure 1 during the notching operation,

fig. 4 shows, in a lateral plan view, a segment of the hollow section notched according to the invention by the device from figures 1 to 3 and having an axial web connecting the diagonally opposite extension sections,

fig. 5 shows the hollow section from figure 4 after the severing and exposing of the extension sections, in a lateral plan view,

fig. 6 shows, in a cross-sectional illustration, the hollow section from figure 5 along section line VI-VI.

A device 1 for producing a hollow section or shell section 2 is shown in figure 1 and contains a hydroforming tool 3. The hydroforming (HF) tool 3 has a top die 4 and a bottom die 5, the cavities 6 of which define a mold space 7, into which the hollow section 2 is inserted. For the shaping expansion of the hollow section 2, an axial plunger 8 closes the respective orifice opening 9 of an end 10 of the hollow section 2. In the present exemplary embodiment, the end 10 is shaped like a bottle neck by the internal high pressure, exerted in the

hollow section interior 11, of a pressure fluid introduced via the axial plunger 8. On that side of the bottle neck 12 which is remote from the axial plunger, passages 13 are formed in the top die 4 and the bottom die 5, and notching punches 14 which are radially displaceable with respect to the hollow section 2 are arranged in said passages 13. The notching punches 14 are arranged offset from one another in the peripheral direction. Adjoining the side 35 of the notching punches 14 which faces the bottle neck 12 is a cutting device which is likewise designed as notching punches 15 and is guided in a displaceable manner in passages 16 of the HF tool 3 radially relative to the hollow section 2. Whereas the notching punches 14, as can be seen in figure 2, are arranged merely in the corner region 17 of the hollow section 2 of box-shaped design and can act upon the latter only at this location, the notching punches 15 of the cutting device are arranged in the region of the longitudinal sides 18 of the hollow section 2 in the HF tool 3 and can only act upon said longitudinal sides 18 (figure 3). The notching punches 15 are therefore arranged offset from the notching punches 14 in such a way that the notching punches 15 almost completely cover the arrangement gaps 19 between the notching punches 14 and the notching punches 14 almost completely cover the arrangement gaps 20 between the notching punches 15. Furthermore, the notching punches 15 are thus arranged outside the engagement region of the notching punches 14 in such a way as to be axially offset from the latter. However, as stated, they adjoin one another almost directly in the peripheral direction of the tool cavity 6.

After shaping has been effected by means of internal high pressure, the notching punches 14 are retracted suddenly in their passages 13 in this exemplary embodiment. In the

process, a cutting edge 21 extending along the passage margins and formed on the cavities 6 of the top die 4 and the bottom die 5 is exposed, the hollow section 2 being trimmed along said cutting edge 21, with notches 22 and in each case an associated notch slug 23 being formed. In this case, the notch slug 23 butts against the end face 24 of the respective notching punch 14 and, driven by the internal high pressure still applied, is pressed together with said notching punch 14 into the passage 13. After that or even at the same time, the notching punches 15 are displaced according to figure 3 toward the hollow section 2, punch notch slugs 25 out of the latter and plunge together with said notch slugs 25 into the hollow section interior 11. After notching has been effected, the notching punches 15 are retracted into their passages 16. In principle, it is also conceivable that the mode of displacement of the notching punches 15 and 14 for forming the notches can be kinematically reversed. The pressure fluid is then relieved and directed out of the hollow section interior 11. After that the HF tool 3 is opened and the hollow section 2 thus trimmed at the periphery at an axial distance from its end 10 is removed from said HF tool 3. The hollow section 2 which can be seen from figure 4 accordingly has notches 22 and notches 26 which are axially offset from one another and are in each case spaced apart separately in the peripheral direction. Extension sections 27 and 28 remain between the notches 22 and between the notches 26, the extension sections 27 being connected to the extension sections 28 at the notch margins 29 by a thin, axial web 30. On account of its notches 26, the extension section 27 is therefore almost completely cut through at its terminating edge 31 and the extension section 28 is almost completely cut through at its terminating edge 32 by the notches 22. In order to divide the hollow section 2 produced in such a way into two parts 33 and 34 in the

region of the notches 22 and 26, the hollow section 2 is severed at the location of the webs 30 outside the HF tool 3 by means of a parting device (not explained in any more detail here), which results in a component 33 as can be seen from figure 5 and figure 6. The extension sections 27, the terminating edges 31 of which are now completely exposed, are bent over by means of a bending device (likewise not explained in any more detail here) to form a flange section of the hollow section or shell section. The webs 30 may possibly also already break off when being cut through on account of their stretching in the case of a very small wall thickness, so that a separate parting device outside the hydroforming tool can be dispensed with.